Design 6-D Cooling Demonstration Experiment

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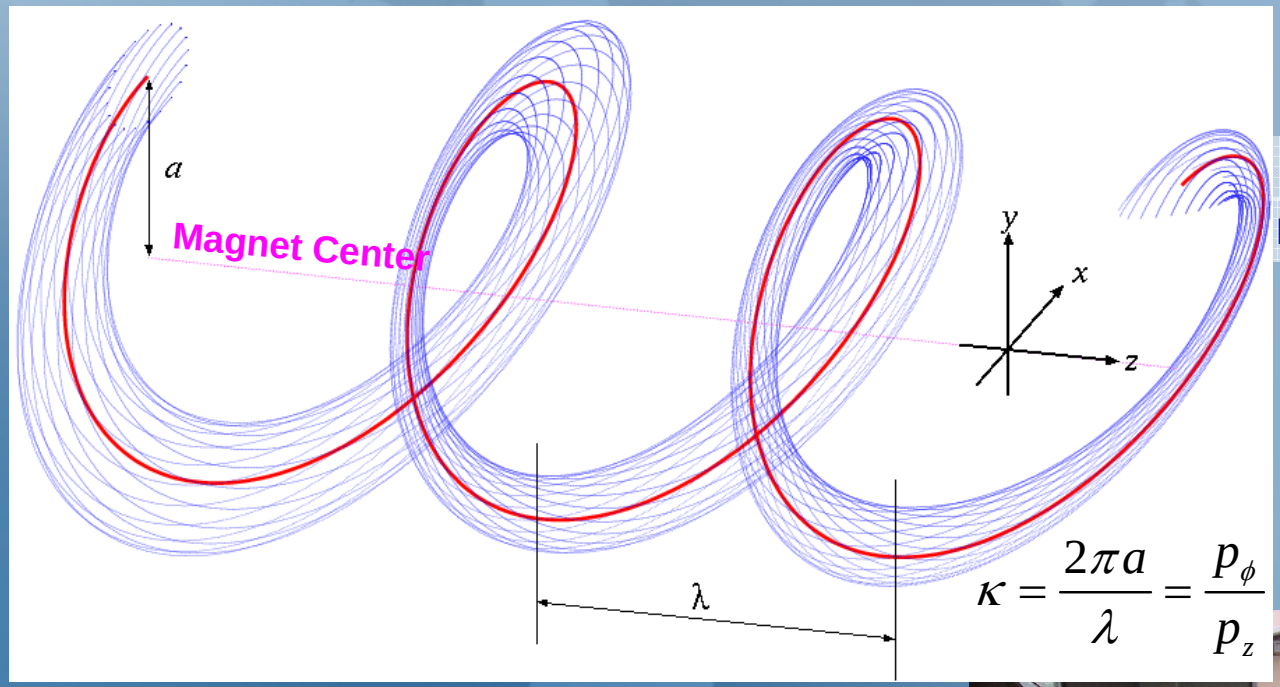
NFMCC Meeting 2006 @ IIT

6-D demonstration experiment

- Build Helical Cooling Channel (HCC)
  - Muon collider And Neutrino factory eXperiment (MANX).
- Proof exceptional 6-D cooling mechanism
  - Show longitudinal phase space cooling
    - Y. Derbenev & R. Johnson ***PRSTAB 8, 041002 (2005)***
- Test engineering availability
  - Coil
  - Cryostat
  - Windows
  - Thermal properties

Particle tracking in Helical Magnet



Red: Reference orbit

Blue: Beam envelope

Combined function magnet
= Helical Dipole + Quadrupole
(+ Sextupole) coils + Solenoidal coil

AGS Helical Magnet
(Siberian Snake: Spin rotator)

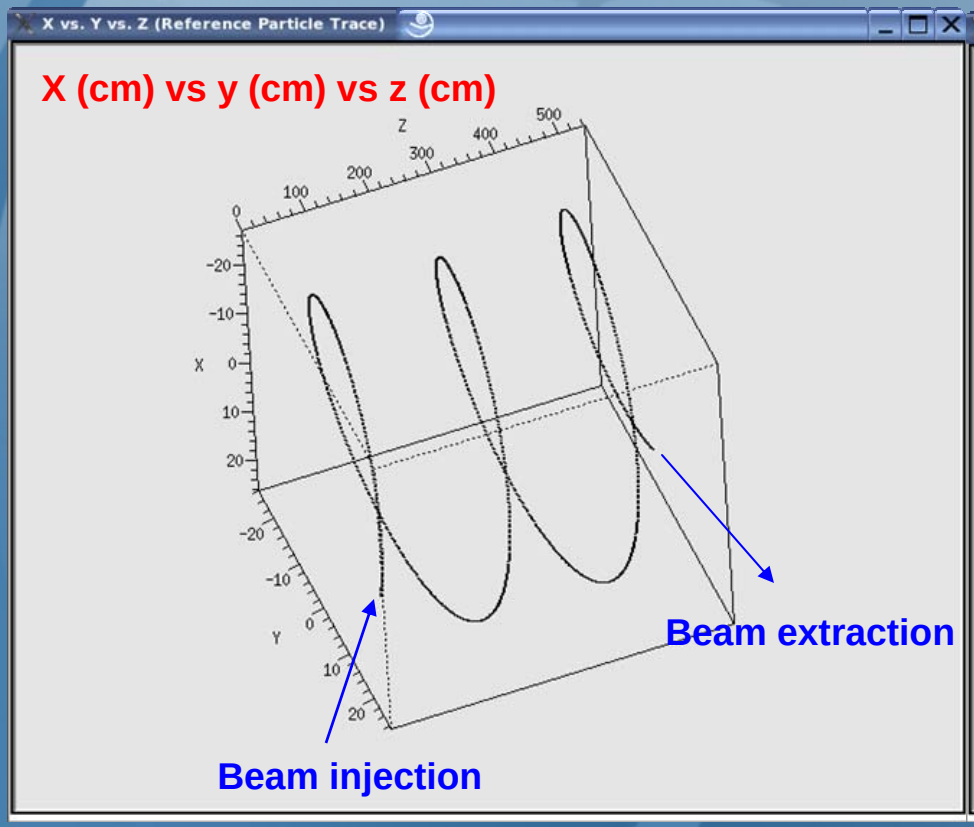
Tip: Demo channel design

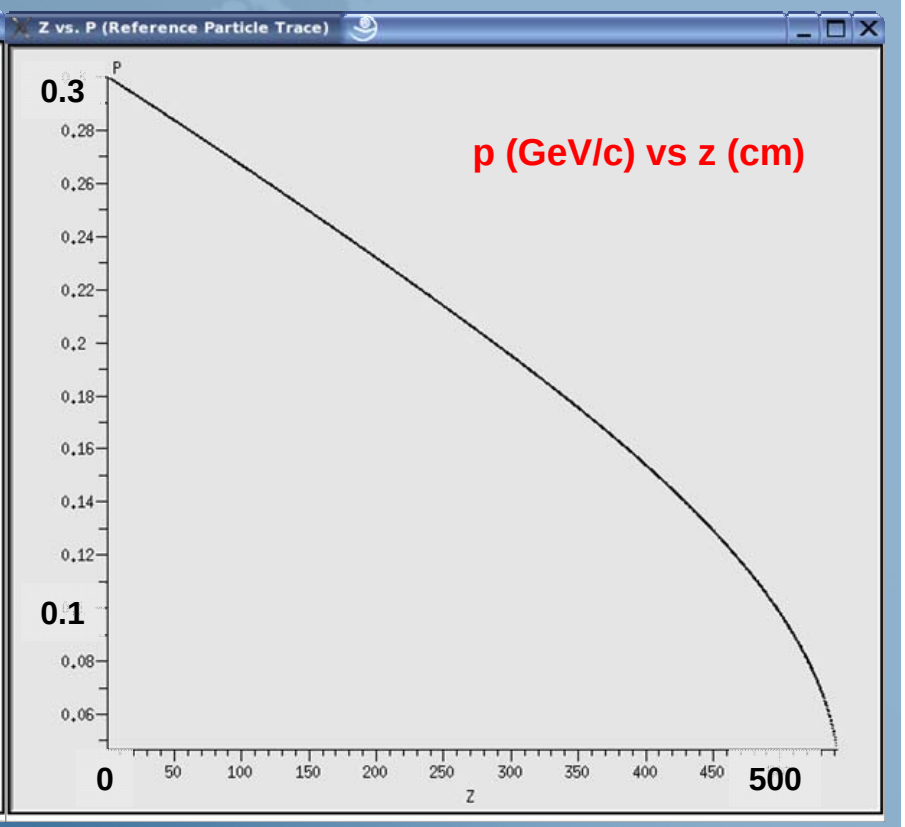
- Use liquid helium (LHe) as absorber
  - No big safety issue
  - Thin windows at both ends of channel
- No RF cavity inside HCC
  - Save R&D time & money
- Momentum dependent (z-dependent) field map
  - Maximum field must be less than 6 T

Helix parameters

- Total length = 4 ~ 5 meters
- Helix period = 2 meters
- $\kappa = 0.8$
- Initial P = 300 MeV/c
- Final P = 100 ~ 50 MeV/c

Momentum reduction in absorber





Reference particle tracking and its momentum reduction in LHe HCC

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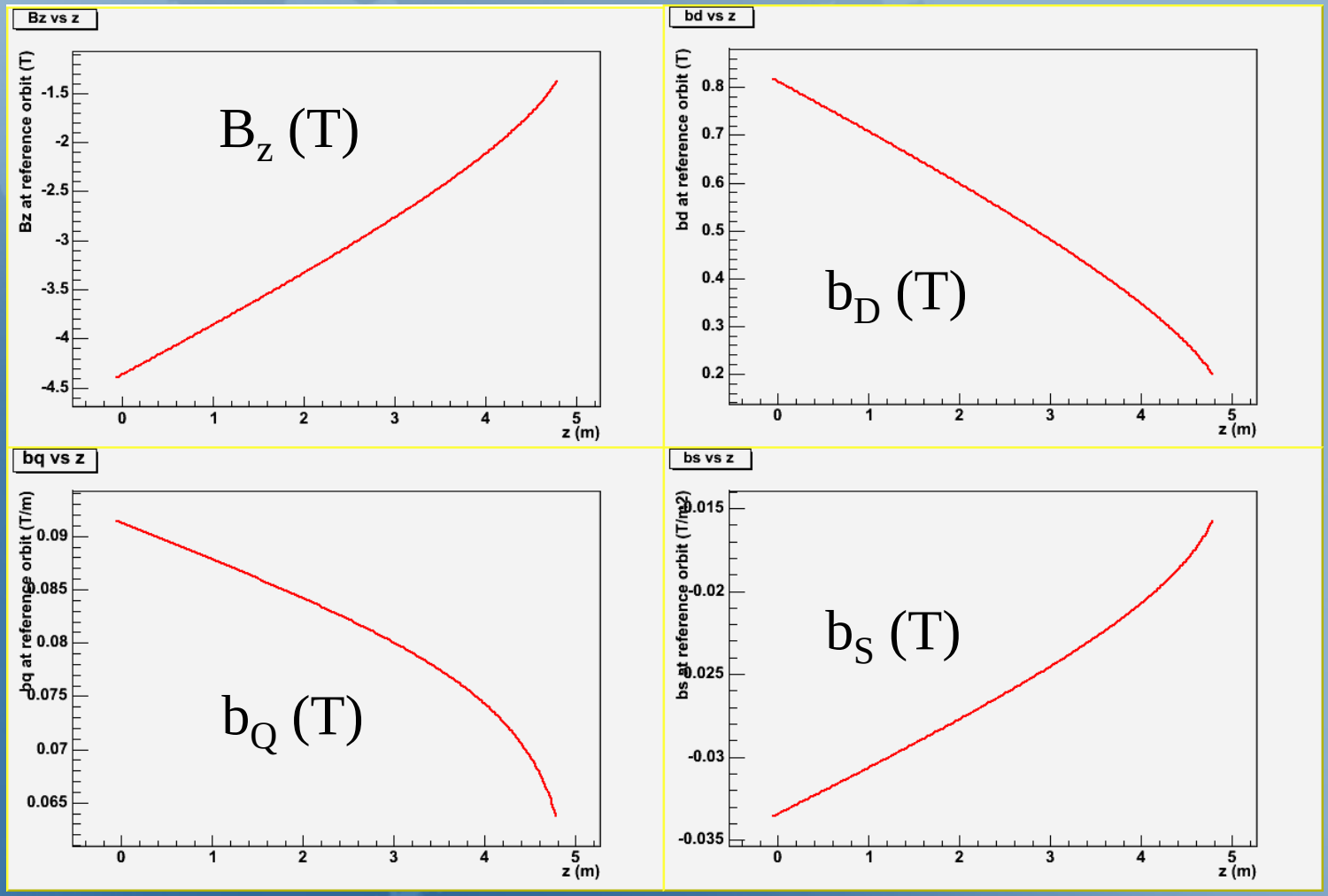
Field strength reduction

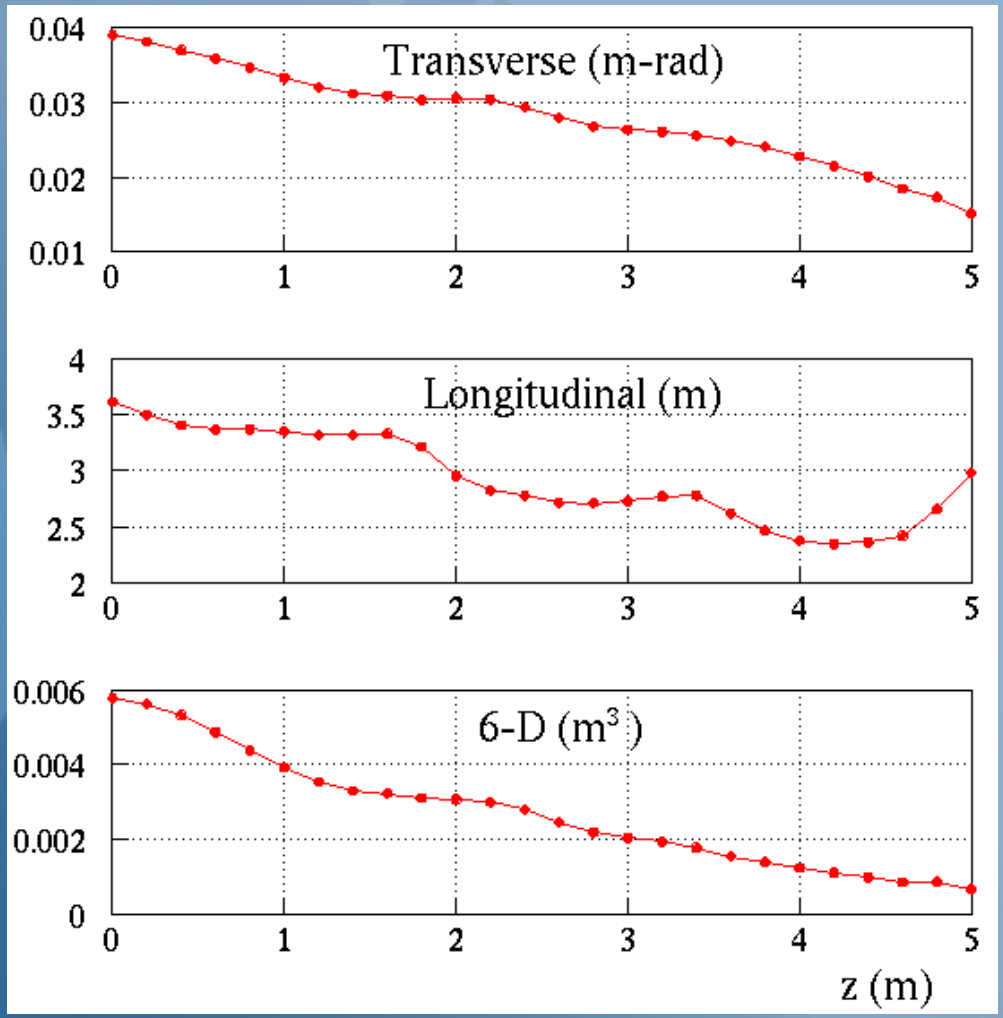


Coefficients of multiple field components

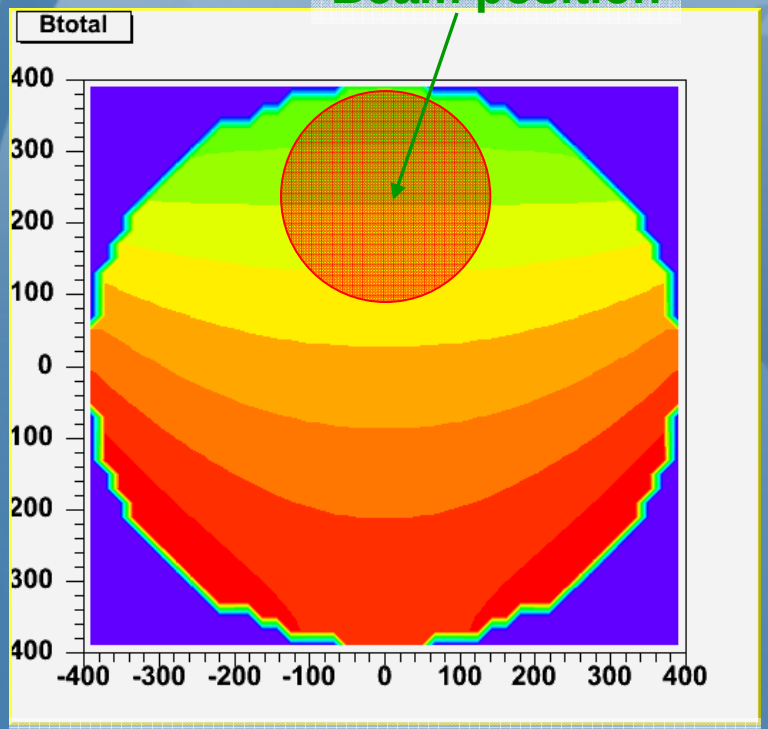
Bz: solenoid, bD: dipole, bQ: quadrupole, bS: sextupole

Emittance evolution in LHe HCC

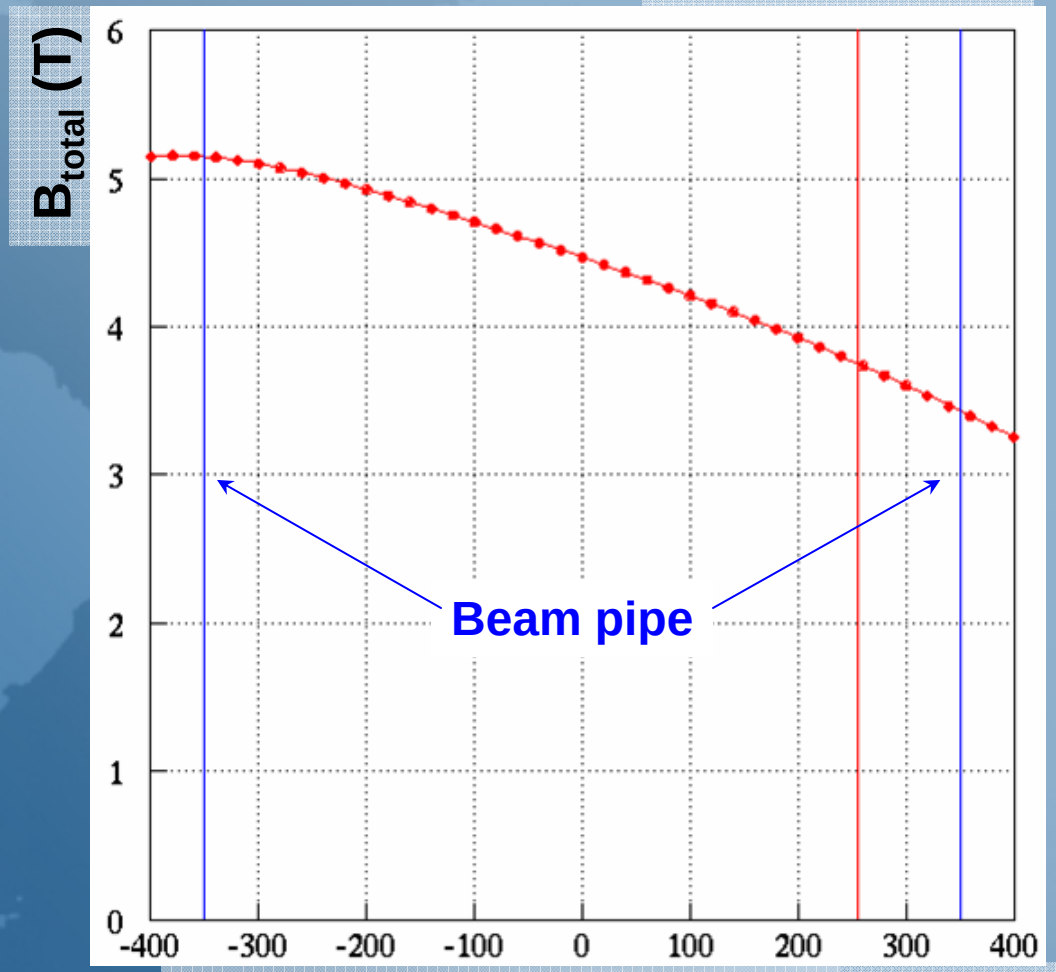
- Clearly see transverse/longitudinal oscillations which are caused by the beta oscillation.
- Longitudinal heating takes place at the end of channel. It is cause by a lower momentum paticle making a longer bunch length.



Maximum B_{total} field in LHe HCC



Contour plot of B_{total} in LHe HCC



Cross Section of B_{total} on y axis

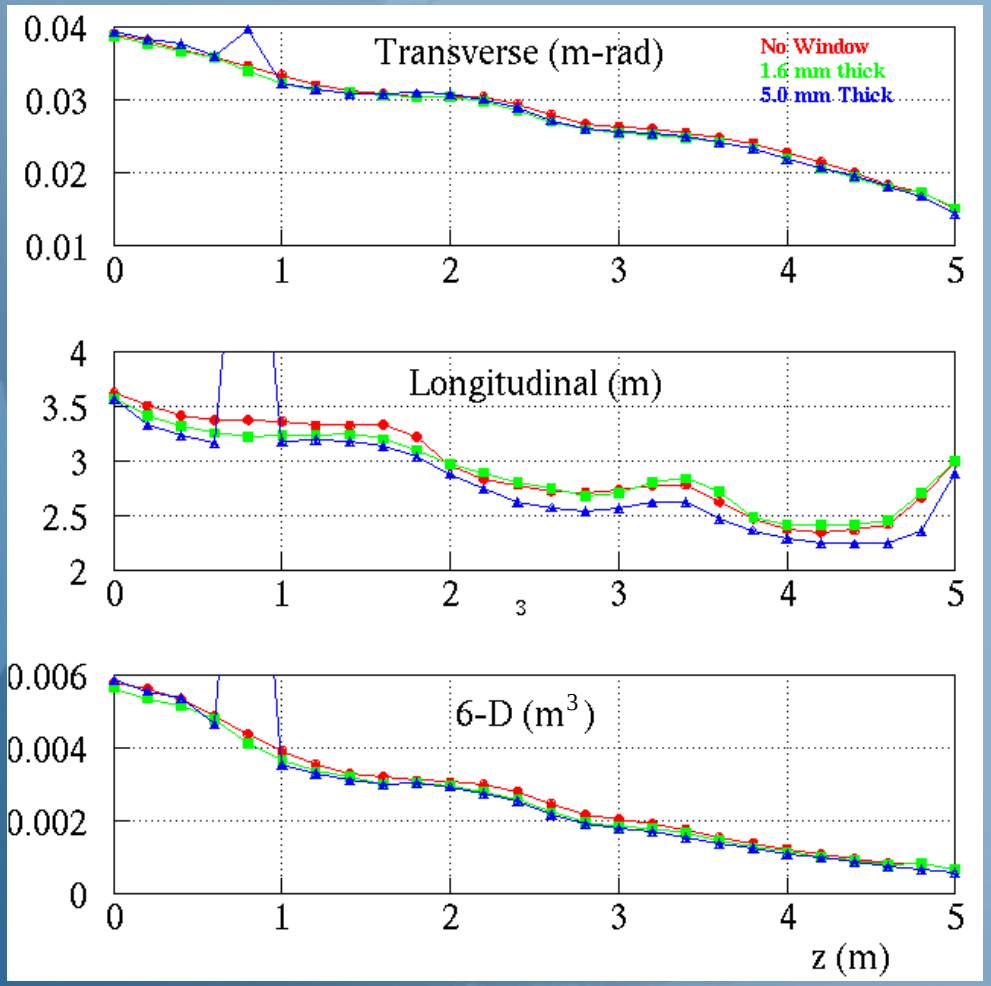
Simulation results

- Transverse cooling factor is 1.7 @ z=4m,
- Longitudinal cooling factor is 1.5 @ z=4m,
- 6D cooling factor is 4.5 @ z=4m.

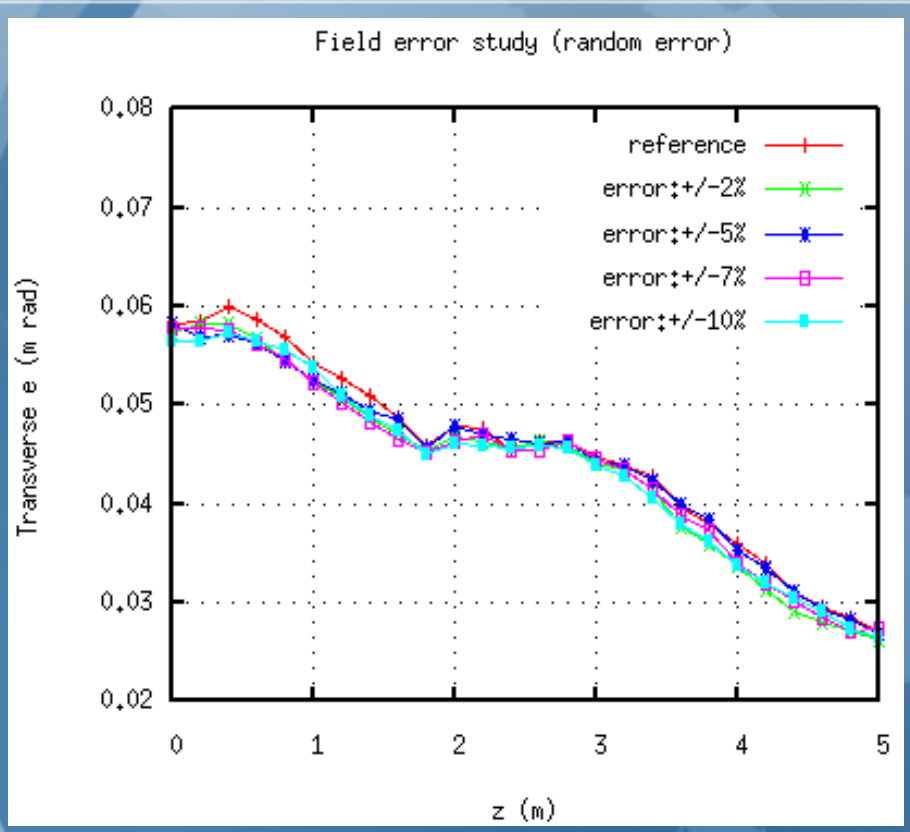
- The maximum field strength can be less than 6 Tesla at the conductor.

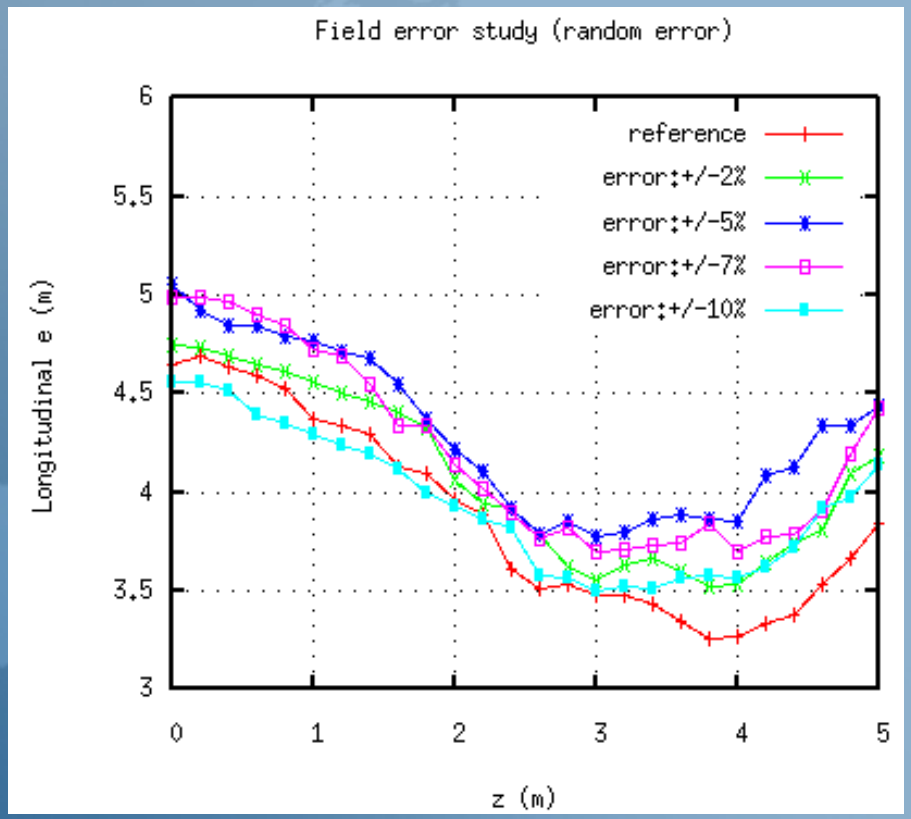
Window effects

- Use Aluminum for window material



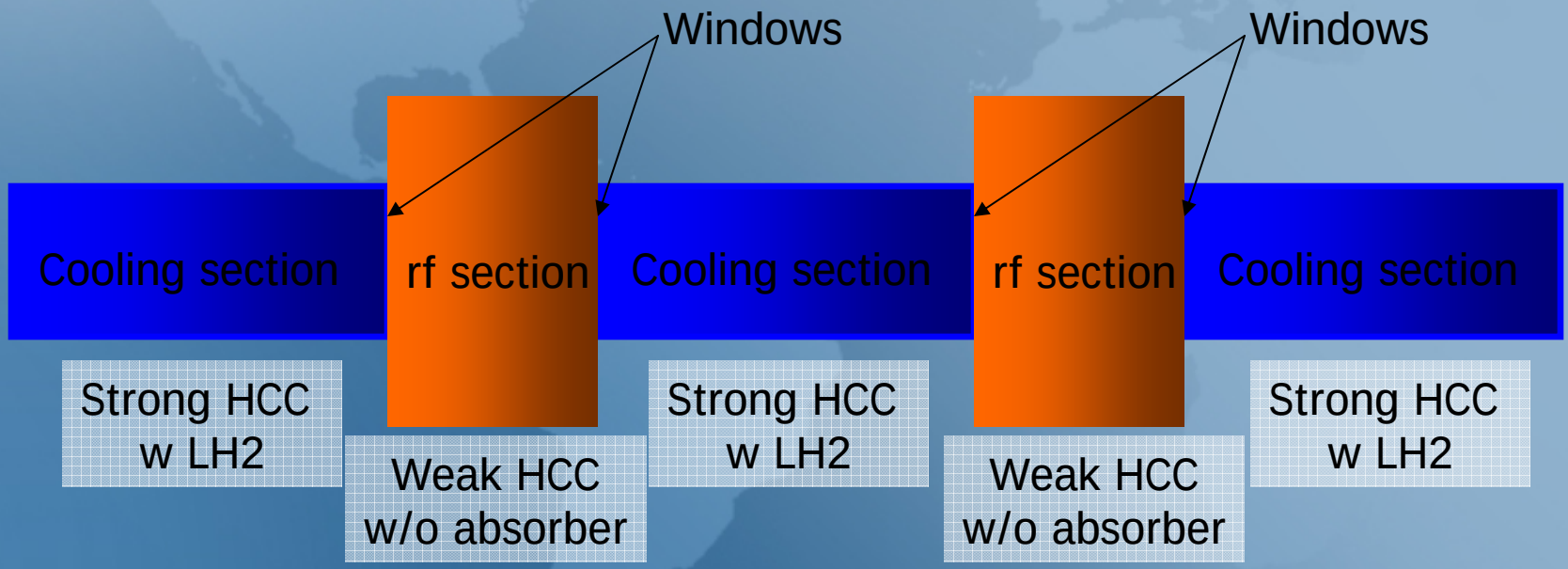
Apply random field errors in bx, by, bz





No serious problem found.

Possible MANX design



Toward to demo experiment

- More simulation
  - Need FEM calculation to take into account end effect and fringe field
  - Solve matching problem
- Beam line(s)
  - Fermilab, BNL, RAL, CERN, etc
- Engineering investigations
- Design spectrometer
- Find collaborators

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